

## CLAIMS

What is claimed is:

1. A method of generating a H<sub>2</sub> rich gas from a fuel, comprising:  
supplying a mixture of molecular oxygen, fuel, and water to a fuel processor; and  
5 converting the mixture of molecular oxygen, fuel, and water in the fuel processor to  
the H<sub>2</sub> rich gas, wherein the fuel has the formula C<sub>n</sub>H<sub>m</sub>O<sub>p</sub> where n has a value ranging  
from 1 to 20 and is the average number of carbon atoms per molecule of the fuel, m  
has a value ranging from 2 to 42 and is the average number of hydrogen atoms per  
molecule of the fuel, p has a value ranging from 0 to 12 and is the average number of  
10 oxygen atoms per molecule of the fuel, and further wherein the molar ratio of  
molecular oxygen supplied to the fuel processor per mole of fuel is represented by the  
symbol x and has a value ranging from about 0.5x<sub>0</sub> to about 1.5x<sub>0</sub>, wherein x<sub>0</sub> is equal  
to  $0.312n - 0.5p + 0.5(\Delta H_{f, \text{fuel}}/\Delta H_{f, \text{water}})$  where n and p have the values described  
above,  $\Delta H_{f, \text{fuel}}$  is the heat of formation of the fuel, and  $\Delta H_{f, \text{water}}$  is the heat of formation  
15 of water.
2. The method of claim 1, wherein converting the mixture of  
molecular oxygen, fuel, and water in the fuel processor to produce the H<sub>2</sub> rich gas  
further comprises contacting the mixture of molecular oxygen, fuel, and water with a  
catalyst in the fuel processor to produce the H<sub>2</sub> rich gas.
- 20 3. The method of claim 1, wherein the molar ratio of molecular  
oxygen supplied to the fuel processor per mole of fuel is x and has a value ranging  
from about x<sub>0</sub> to about 1.5x<sub>0</sub>.
4. The method of claim 1, wherein the molar ratio of molecular  
oxygen supplied to the fuel processor per mole of fuel is x and the molar ratio of water

supplied to the fuel processor per mole of fuel is a value ranging from about  $0.8(2n - 2x - p)$  to about  $2.0(2n - 2x - p)$ .

5        5.        The method of claim 4, wherein the molar ratio of water supplied to the fuel processor per mole of fuel is a value ranging from about  $0.9(2n - 2x - p)$  to about  $1.5(2n - 2x - p)$ .

6.        The method of claim 5, wherein the molar ratio of water supplied to the fuel processor per mole of fuel is a value ranging from about  $0.95(2n - 2x - p)$  to about  $1.2(2n - 2x - p)$ .

10       7.        The method of claim 6, wherein the molar ratio of water supplied to the fuel processor per mole of fuel is a value ranging from about  $1.0(2n - 2x - p)$  to about  $1.1(2n - 2x - p)$ .

8.        The method of claim 1, wherein the molecular oxygen is supplied to the fuel processor in a mixture of gases comprising  $N_2$  and molecular oxygen.

15       9.        The method of claim 1, wherein the mixture of gases comprising  $N_2$  and molecular oxygen is air.

20       10.       The method of claim 1, wherein the fuel is selected from the group consisting of methane, methanol, ethane, ethylene, ethanol, propane, propene, i-propanol, n-propanol, butane, butene, butanol, pentane, pentene, hexane cyclohexane, cyclopentane, benzene, toluene, xylene, natural gas, liquefied petroleum gas, iso-octane, gasoline, kerosene, and diesel.

11.       The method of claim 10, wherein the fuel is selected from the group consisting of methane, natural gas, propane, methanol, ethanol, liquefied petroleum gas, gasoline, kerosene, and diesel.

12. The method of claim 1, wherein the fuel processor comprises a reforming portion and the H<sub>2</sub> rich gas exiting the reforming portion is maintained at a temperature of from about 100°C to about 900°C.

13. The method of claim 1 wherein the fuel processor comprises a reforming portion and the H<sub>2</sub> rich gas exiting the reforming portion is maintained at a temperature of from about 400°C to about 700°C.

14. The method of claim 1, wherein the molar ratio of molecular oxygen supplied to the fuel processor per mole of fuel is  $x$  and has a value ranging from about  $0.8x_0$  to about  $1.4x_0$ .

15. The method of claim 14, wherein the molar ratio of molecular oxygen supplied to the fuel processor per mole of fuel is  $x$  and has a value ranging from about  $0.9x_0$  to about  $1.3x_0$ .

16. The method of claim 15, wherein the molar ratio of molecular oxygen supplied to the fuel processor per mole of fuel is  $x$  and has a value ranging from about  $0.95x_0$  to about  $1.2x_0$ .

17. The method of claim 16, wherein the molar ratio of molecular oxygen supplied to the fuel processor per mole of fuel is  $x$  and the molar ratio of water supplied to the fuel processor per mole of fuel is a value ranging from about  $1.0(2n - 2x - p)$  to about  $1.1(2n - 2x - p)$ .

18. The method of claim 2, wherein the catalyst comprises a two part catalyst comprising a transition metal and an oxide-ion conducting portion, and the mixture of molecular oxygen, fuel, and water is contacted with the catalyst at a temperature of 400°C or greater.

19. The method of claim 18, wherein the transition metal is selected from the group consisting of platinum, palladium, ruthenium, rhodium, iridium, iron, cobalt, nickel, copper, silver, gold, and mixtures thereof, and the oxide-ion conducting portion of the catalyst is selected from a ceramic oxide from the group crystallizing in the fluorite structure or  $\text{LaGaO}_3$  or mixtures thereof.

20. The method of claim 2, wherein the catalyst is selected from the group of autothermally reforming catalysts that operate at a temperature ranging from about  $100^\circ\text{C}$  to about  $700^\circ\text{C}$ .

21. The method of claim 2, wherein the  $\text{H}_2$  rich gas comprises carbon monoxide and carbon dioxide, and the method further comprises contacting the  $\text{H}_2$  rich gas with a second catalyst effective at converting carbon monoxide and water into carbon dioxide and  $\text{H}_2$  to produce a second gas further enriched in  $\text{H}_2$  and with a reduced level of carbon monoxide.

22. The method of claim 21, wherein the second catalyst comprises a transition metal on cerium oxide or on ceria doped with a rare earth or an alkaline earth element, further wherein the transition metal is selected from the group consisting of platinum, palladium, nickel, iridium, rhodium, cobalt, copper, gold, ruthenium, iron, silver, and combinations thereof, the rare earth element is selected from the group consisting of gadolinium, samarium, yttrium, lanthanum, praseodymium, and combinations thereof, and the alkaline earth element is selected from the group consisting of magnesium, calcium, strontium, barium, and combinations thereof.